

II. Status of the Species/Critical Habitat

A. Species/Critical Habitat Description

Pecos Bluntnose Shiner

Description of the Species

Historically, bluntnose shiner, *Notropis simus* (Cope), was found in main channel habitats of the Rio Grande, Rio Chama, and Pecos River, New Mexico and Texas (Cope and Yarrow 1875, Evermann and Kendall 1894, Koster 1957, Chernoff et al. 1982, Hatch et al. 1985, Bestgen and Platania 1990). The total range of the species, based on collected specimens, was 827 river miles (mi) (1,332 kilometers [km]) (C. Hoagstrom, Service, pers. comm. 2002). Concern for the species began in the 1970's, when it was listed as endangered by the American Fisheries Society (Deacon et al. 1979, Williams et al. 1989), and by the Texas Organization for Endangered Species (Anonymous 1987). Concern proved valid for the Rio Grande subspecies (*Notropis simus simus*) which was last collected in 1964 and determined to be extinct during the 1970's (Chernoff et al. 1982, Williams et al. 1985, Miller et al. 1989, Bestgen and Platania 1990, Sublette et al. 1990, Hubbs et al. 1991). As a result, the Pecos River subspecies (*Notropis simus pecosensis* Gilbert and Chernoff), was given formal protection by the state of New Mexico in 1976 (listed as endangered, Group 2) and the state of Texas in 1987 (chapter 68 of the Texas Parks and Wildlife Code). In 1987, the shiner was listed as threatened with critical habitat by the Service (1987).

The shiner is a true minnow (family Cyprinidae) in the genus *Notropis* (Chernoff et al. 1982), and the subgenus *Alburnops* (Etnier and Starnes 1993). Members of the genus *Notropis* are commonly referred to as 'the true shiners' (Jenkins and Burkhead 1994). The shiner shares the typical characteristics of the genus in that they do not have a frenum (a bridge of skin-covered tissue binding snout to the upper lip) and lack a barbel (a slender fleshy protuberance, found on lip, jaw, or elsewhere on the head of some fishes) (Sublette et al. 1990, Jenkins and Burkhead 1994). Members of the subgenus *Alburnops* lack bright breeding coloration, are found in big rivers, have small tubercles on dorsal surfaces of the head, and have pectoral fin rays 1 or 2 through 7 to 9 (Chernoff et al. 1982). The shiner is distinguished from other members of the subgenus *Alburnops* because it commonly possesses as many as 9 anal rays (soft, segmented support structures in the anal fin) (Chernoff et al. 1982, Sublette et al. 1990).

The shiner is a relatively small, moderately deep-bodied minnow, rarely exceeding 3.1 inches (in) (80 mm) total length (TL) (Propst 1999). It has a deep, spindle-shaped silvery body and a fairly large mouth that is overhung by a bluntly rounded snout and a large subterminal mouth. The fish is pallid gray to greenish brown dorsally and whitish ventrally. A wide silvery lateral stripe extends from the pectoral girdle to the base of the caudal fin. Pelvic and anal fins lack pigmentation, dorsal and pectoral fins have small black flecks along the fin rays, and the caudal fin is variably pigmented. Adult shiners do not exhibit sexual dimorphism except during the reproductive period, when the female's abdomen becomes noticeably distended and males develop fine tubercles on the head and pectoral fin rays.

The historic range of the shiner in the Pecos River was 392 river mi (631 km) from Santa Rosa, New Mexico to the New Mexico-Texas border (Delaware River confluence). At the time of listing (1987), the shiner was confined to the mainstem Pecos River from the town of Fort Sumner to Major Johnson Springs, New Mexico (roughly 202 river mi, 325 km) (Hatch et al. 1985, Service 1987). In the 2003 biological opinion (Service 2003a), the range of the shiner was described as from Old Fort Sumner State Park to Brantley Reservoir (194 mi, 318 km), or about 23 percent of the historical range of the species. For purposes of surveys and habitat considerations, the Pecos River from Sumner Dam to Brantley Reservoir was divided into three reaches. The first is the Tailwater reach, which extends from Sumner Dam to the confluence of the Pecos River and Taiban Creek. The second is the Rangelands reach, which extends from Taiban Creek to the Middle Tract of the Bitter Lake National Wildlife Refuge (BLNWRMT). The third reach is from the BLNWRMT to Brantley Reservoir. These reaches will be used throughout the remainder of this biological opinion to describe the condition of the shiner and its habitat.

In the 2003 biological opinion (Service 2003a), the river reach from the FSID Diversion Dam to Bitter Lake National Wildlife Refuge Middle Tract (BLNWRMT) (110 mi, 177 km) was considered the “stronghold” for the shiner, and comprised 13 percent of the historic range of the species (C. Hoagstrom, Service, pers. comm. 2002). This “stronghold” encompassed a portion of the Tailwater reach and all of the Rangelands reach. This reach was considered a stronghold because habitat availability and suitability was the best within the overall range, all size classes of shiner were found, and population numbers were relatively stable (Hoagstrom 2003).

Based on current information presented by Reclamation (Reclamation 2005a) and the NMFRO (Service 2003b), the occupied range of the shiner is more likely defined by the reach of the Pecos River between Taiban Creek and Brantley Reservoir (Rangelands and Farmlands reaches). The reach from the FSID Diversion Dam to Taiban Creek (which includes the reach from Old Fort Sumner State Park to Taiban Creek contained in the Tailwaters reach) does not currently support suitable habitat for the shiner (Hoagstrom 2003). Shiners have not been found in the reach above Taiban Creek since 1999 (S. Davenport, Service, electronic message, 2006a) even though there are no apparent barriers limiting shiner access to this area. Controlled flows, sediment scouring that resulted in channel armoring, and other factors, including the spread of non-native salt cedar are the likely mechanisms for the loss of suitable habitat in this portion of the river. This change in boundary, eliminating the approximately 5 mi (8 km) section between the Old Fort Sumner State Park and Taiban Creek, reduces the occupied range to 186 mi (298 km). The 94 mi (151 km) “stronghold” reach considered in the 2003 biological opinion should also be modified to extend from Taiban Creek to the BLNWRMT, a reduction of 5 mi (8 km) and is defined by the boundary of the Rangelands reach. This does not substantially change the percentage of the historic range currently occupied by the shiner from the 2003 biological opinion.

Critical Habitat

Shiner critical habitat is divided into 2 separate reaches (Service 2003a, Figure 1) and includes a 64 mi (103 km) reach (upper critical habitat) extending from 0.6 mi (1 km) upstream from the confluence of Taiban Creek (river mi 668.9) downstream to the Crockett Draw confluence (river mi 610.4). Only 64 mi (93 km) of the Rangeland reach is included in the upper critical habitat

reach. The Rangeland reach continues downstream for an additional 36 mi (58 km). The lower critical habitat reach is 37 mi (60 km) from Hagerman to Artesia (Service 1987). This portion of the critical habitat is located in the Farmlands reach. These two areas were chosen for critical habitat designation because both sections contained permanent flow and had relatively abundant, self-perpetuating populations of shiner. However, these two areas vary greatly in their habitat characteristics. The upper critical habitat has a wide sandy river channel with only moderately incised banks, and provides habitat suitable for all age classes. The lower critical habitat is deeply incised, has a narrow channel, and has a compacted bed (Tashjian 1993). Although the lower critical habitat has permanent flow, the habitat is less suitable for shiners and only smaller size classes are common in this reach (Hatch et al. 1985, Brooks et al. 1991). Survey data indicate that most of the shiners in the Farmlands reach, including the lower critical habitat unit are young-of-the-year (YOY) and juveniles that may be washed into the area from the upstream Rangelands reach (Service 2003a) and the ability of this area to support self-sustaining populations of the shiner over the long-term is uncertain.

At the time of critical habitat designation, the 114 mi (184 km) portion of the Pecos River between the two critical habitat reaches was subject to frequent drying and therefore was not designated. However, when flow is maintained in this area, as it was between 1991 and 2001, this area contains excellent habitat and supports large numbers of shiners (Hoagstrom 1997, 1999, 2000). The lower 36 mi (58 km) of the Rangelands reach is located in this area and the provision of water provides important habitat to support the shiner population. Flows of 35 cfs at the Acme gage during the winter season (November through February) were also provided in this reach through the requirements of the 2003 biological opinion to ensure maintenance of these habitats in the Rangelands reach. The Pecos River between the two areas of critical habitat is acknowledged as an important component of recovery for the shiner.

Primary constituent elements of the critical habitat are clean, permanent water; a main river channel with sandy substrate; and low water velocity (Service 1987). At the time of listing, sporadic water flow in the river was identified as the greatest threat to the shiner and its habitat. Water diversions, ground and river water pumping, and water storage had reduced the amount of water in the channel and altered the hydrograph with which the shiner evolved. Although block releases maintain the current channel morphology (Tetra Tech 2003), since the construction of Sumner Dam, the peak flow that can be released is much less than the historical peak flows (U.S. Geological Survey historical surface flow data). The altered hydrograph encourages the proliferation of non-native vegetation, such as salt cedar, which armors the banks and causes channel narrowing. Channel narrowing increases water velocity, reduces backwater areas, and leads to the removal of fine sediments such as sand. Consequently, in areas dominated by salt cedar, the habitat becomes less suitable or unsuitable for shiners. Lack of permanent flow and an altered hydrograph continue to be the greatest threats to the shiner and its habitat.

B. Life History

Habitat

Typical of other members of the subgenus *Alburnops* (Etnier and Starnes, 1993), the shiner inhabits big rivers (Chernoff et al. 1982, Bestgen and Platania 1990). It has survived only within

perennial stretches of the middle Pecos River, New Mexico (Hatch et al. 1985, Service 1987). In conjunction with perennial flow, the shiner is found in wide river channels with a shifting sand-bed and erosive banks (Tashjian 1993, 1994, 1995, 1997; Hoagstrom 2000, 2001, 2002). The highly erosive bed and banks allow channel configurations to change in response to flow events (Tashjian 1997, Tetra Tech 2000).

Flood inflows from numerous uncontrolled tributaries contribute to favorable river channel conditions in the Pecos River in the Rangelands reach. Although flood flows from uncontrolled tributaries occur too infrequently to maintain a wide channel, the combination of sediment and floodwater inflows are important for the maintenance of a sand-bed. Throughout the remainder of the historic bluntnose shiner range, closely spaced impoundments that control floods and block sediment transport have virtually eliminated these features (Lawson 1925, Lane 1934, Woodson and Martin 1965, Lagasse 1980, Hufstetler and Johnson 1993, Collier et al. 1996).

Although the shiner is found in the deeply incised lower river stretch that constitutes the Farmlands reach, the population there is dominated by small YOY (Hatch et al. 1985, Brooks et al. 1991, Brooks et al. 1994, Brooks and Allan 1995, Service 2003b), Hoagstrom et al. 1995, Hoagstrom 1997, 1999, 2000, 2001). Lack of growth, reduced survival, and reduced recruitment in this reach is attributed to poor habitat conditions related to the narrow, incised river channel and silt-armored bed. The predominance of YOY shiner in this reach is explained by periodic downstream displacement of eggs, larvae, and small juveniles (Brooks and Allan 1995, Hoagstrom et al. 1995, 1997, 1999, 2000; Platania and Altenbach 1998).

Velocity and Depth Preference

A habitat preference study was conducted from 1992 to 1999, to determine the effects of dam operations and variable flows on habitat availability. Velocity association varies with shiner size; larger fish are found in higher velocities (Hoagstrom 1997, 1999, 2000, 2002). Adults most frequently utilize velocities between 0.33 and 1.4 feet/second (ft/s) (10 and 42 centimeters/s [cm/s]). These velocities are typically found in open-water runs, riffles, and shallow pools (Hoagstrom 2002). Juveniles most frequently utilize velocities between 0.03 and 0.91 ft/s (1.0 and 28 cm/s), which are most commonly associated with shoreline areas (Hoagstrom 2002). Larvae presumably utilize backwater habitats with negligible velocity, relatively high water temperature, and high water clarity (Platania and Altenbach 1998). Thus, a range of velocities is necessary to support all shiner life stages.

Adult shiners most frequently utilize depths between 5.1 and 13 in (13 and 34 cm) (Hoagstrom, 2002). Juvenile shiners utilize a variety of depths from 2 to 17 in (6 to 42 cm) (Hoagstrom 2002). Such depths are generally associated with run, riffle, and shallow pool habitat. Use of a variety of depths may be caused by the need to avoid high velocity areas. However, shallow, low-velocity habitat may be most favorable (Platania and Altenbach 1998). Depths used most often by larvae are unknown.

The habitat preference study found that habitat availability varied between study sites (Hoagstrom 1999, 2000, 2002). Suitable depths and velocities were least abundant in the Farmlands reach (Hoagstrom 2002). The uniformity of the channel creates nearly constant

depths and velocities across the channel at a given discharge. This lack of variability at all flows and lack of shallow depths and low velocity areas at high discharge, greatly reduces the suitability of habitat in this lower reach. In the Ranglands reach between the Taiban Creek confluence and Gasline, the wide, mobile, sand-bed channel meanders from side to side. Because a variety of depths and velocities are present over a wide range of discharges, the availability of suitable habitat is much greater in this reach.

Additional information on habitat availability and use by shiners was provided by Kehmeier et al. (2004) (as cited in Reclamation 2005a). This study evaluated mesohabitat use and availability in the Ranglands reach. Shiners were found to use parallel and perpendicular plunge habitats having moderate velocities and depths. Run and flat-water areas were avoided. Based on volumetric calculations, the authors concluded that the availability of the preferred plunge habitats was less altered by low flows than other types. This information is relevant to the ability of the Ranglands reach to provide sufficient habitat to support shiner populations at varying flow levels. It is important to consider the amount of habitat present at all flow levels, particularly to ensure the amount is adequate to support the desired population levels. Additional review of this information will be important in evaluating changes in future management proposed by Reclamation.

Reproduction (Spawning)

The shiner is a member of the pelagic spawning minnow guild found in large plains rivers (Platania 1995a, Platania and Altenbach 1998). These minnows release non-adhesive, semi-buoyant eggs (Platania and Altenbach 1998). Because these minnow inhabit large sand bed rivers where the substrate is constantly moving, semi-buoyant eggs are a unique adaptation to prevent burial (and subsequent suffocation) and abrasion by the sand (Bestgen et al. 1989). Shiners begin spawning as one-year-olds, once they reach 1.6 in (41 mm) standard length (SL) (Hatch 1982). The spawning season extends from late April through September, with the primary period occurring from June to August (Platania 1993, 1995a). Throughout the reproductive season, spawning is associated with substantial increases in discharge, including flash floods and block releases of water (Platania 1993, S. Platania, University of New Mexico, pers. comm. 2002).

Fecundity varies among individuals. Platania (1993) found that females released an average of 370 eggs with each spawning event and spawn multiple times during the spawning season. Eggs hatch in 24 to 48 hours (Platania 1993). Because the eggs are semi-buoyant, they are carried downstream in the current (Platania 1993, 1995a, Platania and Altenbach 1998). Newly-hatched larvae float downstream for another 2 to 4 days. During this time, blood circulation begins, the yolk sac is absorbed, and the swim bladder, mouth, and fins develop (Moore 1944, Bottrell 1964, Sliger 1967, Platania 1993). As the larvae drift, they “swim up”, a behavior in which they repeat a cycle of swimming towards the surface perpendicular to the current, sink to the bottom, and upon touching substrate, propel themselves back toward the surface (Platania 1993). This behavior allows larvae to remain within the water column and avoid burial by mobile substrate (Platania and Altenbach 1998). Small juveniles are also susceptible to downstream displacement (Harvey 1987), but are better able to seek low-velocity habitats. Channel conditions that reduce downstream displacement and provide low-velocity habitats are favorable for successful shiner

recruitment.

Historically the Pecos River had low, erosive banks, large inputs of sediment from tributaries, and uncontrolled floods. However, downstream displacement of eggs and larvae was minimal because flood peaks were of short duration and backwaters and other low velocity habitat remained abundant at high discharge (Dudley and Platania 1999). In contrast, transport of water in block releases that are part of the current water operation strategy sustains high flows for many days instead of several hours (Dudley and Platania 1999). In addition, where the channel is narrow and incised, backwaters and other low velocity areas are much reduced. Block releases of water stimulate the shiner to spawn (S. Platania, University of New Mexico, pers. comm. 2002), but the eggs, larvae, and small juveniles are then displaced downstream because of the lack of low velocity habitats and the sustained high discharge. Massive downstream displacement from the Rangelands reach accounts for population fluctuation in the deeply incised Farmlands reach (Brooks et al. 1994, Brooks and Allan 1995, Hoagstrom et al. 1995, Hoagstrom 1997, 1999, 2000; Platania and Altenbach 1998). Eggs, larvae, and small juveniles that are transported to Brantley Reservoir likely perish (Dudley and Platania 1999). Some shiner eggs or larvae may be able to pass through Brantley Dam, as indicated by the detection of young shiners below the dam in 2003 (Service 2003b). The ability of these shiners to survive and spawn in this area is unknown.

Food Habits

A short intestine, large terminal mouth, silvery peritoneum, and pointed, hooked pharyngeal teeth indicate that the shiner is carnivorous (Hubbs and Cooper 1936, Bestgen and Platania 1990). Although Platania (1993) found both animal and vegetable matter within shiner intestines, it is possible that vegetation is ingested incidental to prey capture. It is uncertain whether vegetation can be digested in such a short intestine (Hubbs and Cooper 1936, Marshall 1947). Young shiners likely consume zooplankton primarily, while shiners of increasing size rely upon terrestrial and aquatic insects (Platania 1993, Propst 1999). In a cursory analysis of 655 shiner stomachs, Platania (1993) found terrestrial insects (ants and wasps), aquatic invertebrates (mainly dipteran fly larvae and pupae), larval fish, and plant seeds (salt cedar). Other studies have also documented *Notropis* species consuming seeds during winter (Minckley 1963, Whitaker 1977) and it could be that shiners are primarily carnivorous, but utilize less favorable forage such as seeds when animal prey is scarce or that they indiscriminately ingest anything that is of the appropriate size.

The shiner diet is indicative of drift foraging (a feeding strategy where individuals wait in a favorable position and capture potential food items as they float by) (Starrett 1950, Griffith 1974, Mendelson 1975). Drift foragers depend upon frequent delivery of food to offset the energy required to maintain a position in the current (Fausch and White 1981). Water velocity must be adequate to deliver drift (Mundie 1969, Chapman and Bjornn 1969) but low velocity refugia where the fish can rest within striking distance of target items is also necessary (Fausch and White 1981, Fausch 1984). Habitat structure that creates adjacent areas of high and low velocity (e.g., bank projections, debris, bedforms) may be important for shiner feeding. Alluvial bed forms may be the most abundant form of habitat structure in sand-bed rivers (Cross 1967) and these bedforms require a certain velocity for formation and maintenance (Simons and Richardson

1962, Task Force on Bed Forms in Alluvial Channels 1966). Thus, foraging shiners rely upon flow both for delivering food items and for maintaining favorable habitat.

Age and Growth

First year and second year individuals are predominate in the shiner population, comprising 97 percent of captures. Third year individuals are much less prevalent (Hatch et al. 1985). First year individuals grow rapidly, reaching 26 to 30 mm SL within 60 days (S. Platania, University of New Mexico pers. comm. 2002). Hatch et al. (1985) reported that age-0 (first year) shiners ranged from 0.75 to 1.3 in (19.0 to 32.5 mm) SL, age-1 (second year) individuals ranged from 1.28 to 1.77 in (32.6 to 45.0 mm) SL, and that age-2 (third year) individuals ranged from 1.77 to 2.22 in (45.1 to 56.5 mm) SL.

Mean length of the shiners is significantly different between the Rangeland reach (Taiban Creek confluence down to BLNWRMT) and the Farmlands reach (downstream of the BLNWRMT). In the Rangelands reach the mean length of shiners is 1.3 in (34.2 mm), with a standard deviation (SD) of 0.36 in (9.3 mm) (N=7,477). Downstream the mean length is 0.91 in (23.2 mm) with a SD of 0.28 in (7.1 mm) (N=8,876) (C. Hoagstrom, Service, pers. comm. 2002). Most likely the difference in size is related to habitat quality (the downstream Farmlands reach provides less suitable habitat for the growth and survival of the shiner) and the influx of small shiners into this lower reach during high flows including those caused by block releases from Sumner Dam.

Data from 1992 to 1999 (years of high precipitation and experimental base-flow supplementation) suggest that favorable flow conditions produced larger shiners (Hoagstrom 2001). Numerous individuals captured during that period were larger than previously recorded. Abundance of record-length shiners peaked between April and July 1999 when the 16 largest shiners, ranging in size from 2.58 to 3.01 in (65.5 to 76.4 mm) SL were captured (C. Hoagstrom, Service, pers. comm. 2002). Twenty-five percent of the longest shiners caught over an 11-year period (1992 to 2002) were caught in 1999. The longest individual captured in 1999 was 3 in SL (76.4 mm). This specimen was 0.4 in (11.2 mm) longer than any other shiner caught during the 10-year study, 0.3 in (7.5 mm) longer than the longest reported by Platania (1993), 0.8 in (19.9 mm) longer than any reported by Hatch (1982), and 0.9 in (23 mm) longer than the longest from the historical record (Chernoff et al. 1982). Dryer weather has prevailed since 1999, and shiners greater than 2.4 in (60.0 mm) SL have again become uncommon (C. Hoagstrom, Service, pers. comm. 2002). Dry conditions from 2002-2004 likely contributed to the shift in the size of individual shiners back near pre-1992 conditions. Size data from 2005 are not yet available.

Competition and Predation

Non-native fish species, including the plains minnow (*Hybognathus placitus*) and the Arkansas River shiner (*Notropis girardi*) are now established members of the Pecos River fish community. They are also part of the guild defined as broadcast spawners to which the shiner belongs (Platania 1995a). Members of this guild spawn during high flow events in the Pecos River and have semi-buoyant eggs that are distributed downstream to colonize new areas (Bestgen et al. 1989). As a result of the non-native introductions, interspecific competition may be a factor in the reduction in shiner abundance and distribution. Young fishes of these species that also use low velocity backwater areas may compete directly with young shiner for space and food (if food

is limited); however, competitive interactions among Pecos River fishes have not been studied.

Juvenile and adult shiners generally occupy flowing water of low depth (see Velocity and Depth Section). At the same time, flowing water is important for supplying food and creating habitat structure (see Food Habits). Thus, a significant reduction of velocity impacts feeding position and food availability. Under such circumstances, shiners are forced to occupy habitats with lower velocity and more variable depth, but these habitats are commonly occupied by other fish species (Hoagstrom 1999, 2000). At low discharge, competition for space and forage is likely increased (Hoagstrom 1999). Concentration of species is most severe during intermittency because fishes must congregate in remnant pools. In such cases, it is likely that fishes that commonly inhabit still and stagnant waters (e.g., red shiner [*Cyprinella lutrensis*], western mosquitofish [*Gambusia affinis*]) gain a competitive advantage over fluvial species (Cross 1967, Summerfelt and Minckley, 1969). In addition, without flows to deliver food items, species dependent upon drift, such as the shiner, are at a disadvantage (Mundie 1969).

Large-bodied piscivorous fishes in the Pecos River are uncommon in currently occupied shiner habitat between the Taiban Creek confluence and Brantley Reservoir (Hoagstrom 2000, Larson and Propst 2000). This is primarily because the majority of available habitat is shallow. High turbidity likely inhibits sight-oriented predators such as the sunfishes (Centrarchidae). Predators that occupy the most suitable shiner habitat include the native longnose gar (*Lepisosteus osseus*), flathead catfish (*Pylodictis olivaris*), and green sunfish (*Lepomis cyanellus*), and the non-native channel catfish (*Ictalurus punctatus*), white bass (*Morone chrysops*), and spotted bass (*Micropterus punctulatus*) (Larson and Propst, 2000, C. Hoagstrom, Service, pers. comm. 2002). When captured during surveys, the majority of these predators have been small (Larson and Propst 2000, Valdez et al. 2003). Thus, low abundance and small size suggest fish predation is not a major threat to the shiner (Larson and Propst 2000). However, the impacts of predaceous fishes within intermittent pools have not been studied and it is possible that they feed on shiners (Larson and Propst 2000). With the increase in intermittent flow days in 2002-2003 (number intermittent days: 2002 [53 days] and 2003 [47 days]) there may have been an increased risk of predation on shiners caught in pools. The reduction in intermittent flow days in 2004 to eight days, and none in 2005, reduced that risk of predation. By maintaining continuous flow in 2006, the degree of risk from predation should continue to be reduced.

Aerial and terrestrial piscivores may also threaten the shiner. Although neither group appears especially abundant along the Pecos River (C. Hoagstrom, Service, pers. comm. 2002), many piscivorous birds are seasonally found at BLNWRMT and piscivorous mammals and reptiles are present along the river. Least terns are known to prey on shiner species in other rivers (Wilson et al. 1993, Schweitzer and Leslie 1996), but this has not been documented on the Pecos River. As with piscivorous fishes, impacts of non-aquatic predators (e.g. racoons, skunks, coyotes) on the shiner are likely most significant during surface flow intermittence, when fishes are confined and crowded in shallow water (Larimore et al. 1959).

C. Population Dynamics

Based on seine collections (0.12 in, 3.0 mm mesh), shiner population structure is bimodal (two distinct length classes) from May through August (Hoagstrom 2003). The smaller size class includes YOY and juveniles; the larger size class, adults. In the spring (January through April) the population is unimodal (one size class) as first year individuals complete a growth spurt and third year individuals decline in abundance (Hoagstrom 2003). Large juveniles and adults dominate the population at this time. Young-of-the-year present in May and June are not collected with the seine because they are small enough to pass through the mesh.

Within the Pecos River, two population trends are exhibited. In the Rangelands reach, all age groups are present and adults dominate the population. In contrast, in the Farmlands reach, adults are rare and YOY dominate (Hatch et al. 1985, Brooks et al. 1991, Brooks and Allan 1995, Service 2003b, Hoagstrom et al. 1995, Hoagstrom 1997, 1999, 2000, 2001). In the upstream Rangelands reach, fish community composition was found to be stable among years and seasons (Hoagstrom 2000). Shiner abundance varied among years, but was relatively stable within years (seasonally) (Hoagstrom 2000, 2001). In contrast, downstream in the Farmlands reach fish community composition was unstable among years and seasons and shiner abundance fluctuated widely both within and among years (Hoagstrom 2000, 2001). This relationship held true for both reaches through 2001. In 2002, relative abundance of shiners in both the upstream and downstream reaches declined precipitously beginning in the second trimester (May-August) survey period (Fagan 2006). There was some rebound in early 2003, but by the end of that year, relative abundance, shiners as a percentage of the shiner guild, and density were at or near 1992 levels (Service 2003b, Fagan 2006).

Early studies showed that shiners avoid (or perish within) areas subjected to frequent surface flow intermittence (Hatch et al. 1985, Brooks et al. 1991). Subsequent studies found that shiners proliferated in areas that were formerly intermittent when they remained perennially wet (e.g. the middle reach of the Pecos River between the two critical habitat segments) (Hoagstrom 1997, 1999, 2000, 2001). Favorable flow conditions between 1992 and 1999 corresponded with increased shiner density in the middle reach (Hoagstrom 2000, 2001) and large individual size (see Age and Growth).

In 1992, New Mexico Fishery Resources Office (NMFRO) began a 5-year study on the shiner and its habitat. This study was extended beyond the original 5-years and is ongoing. Research on the shiner population has continued, resulting in a 13-year record of population trends (data analyzed from 1992-2004). From February 1992 through August 2002, 803 fish collections were made, capturing 19,525 shiners (density = 0.09 shiner/m²) (C. Hoagstrom, Service, pers. comm. 2002). In 2003-2004 an additional 105 fish collections were made with 81 of those containing the shiner. Over the 13-year period, only 23 shiners have been caught in the Tailwaters reach. Although at the time of listing (1987) shiners were relatively common from the FSID Diversion Dam down to Taiban Creek, they have become more rare in this part of the river and now are infrequently collected (Hoagstrom 2003). The remainder of this discussion will focus on the Rangelands and Farmlands reaches that remain occupied by the shiner. The Tailwaters reach will not be discussed further.

Between 1992 and 2001, shiner density increased from the January-April sampling period to the

May-August sampling period in seven of the 10 years in the Rangelands reach (Figure 4). In those years (1995-1997) where declines were observed between the first and second trimesters, these declines were small and populations had increased by the end of the third trimester. In 2002, the decline between these same two trimesters was 75 percent over the previous sampling period. Not only is it unusual to see a decline between these two sampling periods but the magnitude of decline seen in 2002 is much greater than has been recorded before. Two factors contribute to the decline. First, there were two periods of stream drying between May and August 2002, which led to the death of shiners (D. Propst NMDGF, pers.comm. 2002). Second, because stream flow was low during the January-April 2002 sampling period, fish were concentrated and much easier to capture. The very high density recorded in January-April may be in part an artifact of sampling during low flows. However, flows were also low during the May-Aug collection. Ease of capture may in part explain the high density values seen in 2001 as well.

In 2003, shiner density was considerably higher in the January-April period in the Rangelands reach than at the end of 2002, but did not significantly change between January-April and May-August. Densities dropped to 1992 levels by the last sampling period (Fagan 2006). High capture rates in the first two sampling periods may relate to the same issues as in the discussion about 2002 captures.

In 2004, January-April shiner densities remained near 1992 starting levels in the Rangelands reach and remained considerably below 2003 levels for the May-August period and were at very low levels at the end of 2004. While 2004 had fewer days of no-flow at the Acme gage than in 2003 (8 days versus 44), the lingering effects of the low 2003 population numbers to provide for the breeding population in 2004 may have been a factor in continued low levels. In Figure 4, notice the pattern in 1992-1995 where populations were generally low. Several years of good flows were needed before the population densities increased significantly. It is also important to consider the manner in which flows move through the system. Shiners spawn in response to sudden peaks in flow. Optimal years may then be those with the necessary peaks that also have sufficient base flows to ensure that nursery habitat exists and eggs and larvae are retained in areas of good habitat. Years with a steady flow may not provide the appropriate cues for spawning. Years with very high spikes and very low baseflows may have significant movement of eggs and larvae out of good habitat areas, thus potentially reducing survival.

The relative abundance of shiners in the fish community in the Rangelands reach showed a gradual increase over time, especially between 1995 and 2002 (Figure 5). This indicates that shiners became a more abundant component of the fish community over time, reaching a high of 25.6 percent in the January-April 2002, sampling period. The overall trend was likely the result of high precipitation and experimental base-flow supplementation until 2000. The precipitous drop in the May-August 2002 sampling period may indicate that shiners are more susceptible to drying conditions than are other species in the fish community. For instance, red shiners typically occur in harsh, unpredictable environments with temperature extremes and episodes of low oxygen, floods, and drought (Matthews et al. 2001). Data from NMFRO and Valdez et al. (2003) indicate that the percent abundance of shiner decreased to about 5 percent of the shiner guild in October 2002 while the percent abundance of red shiner markedly increased. In 2003,

relative abundance of shiners increased somewhat over the lows seen in 2002 in the first two trimesters, and then decreased significantly to 1992 levels. Data from 2004 show further declines in shiner relative abundance and density (Fagan 2006). Data from the first two trimesters in 2005 again showed declines when compared to the comparable trimesters in 2004 (Fishery Resources Office 2006). Based on the first two trimesters in 2005, values river-wide are the lowest recorded since monitoring began in 1992 (Fishery Resources Office 2006).

Shiner relative abundance and density in the Farmlands reach have not shown any distinct trends over the last 13 years (Figures 6 and 7). Both measures have been highly variable over this time frame. Similar to the Rangelands reach, shiner density increased in 2001. This is likely due to increased sampling efficiency because of low flows (C. Hoagstrom, Service, pers. comm. 2002). Both density and relative abundance declined precipitously in late 2002 through 2003 with no appreciable recovery in 2004. Although shiner density has shown sporadic increases, it is nearly always followed by a decrease in the Farmlands reach. There has been a decreasing trend in shiner density or relative abundance in the Farmlands reach.

Population fluctuation in the Farmlands reach is largely attributable to Sumner Dam operations (Hoagstrom 1997, 1999, 2000). After block releases of water (> 15 days in duration) numerous shiner eggs, larvae, and juveniles are displaced downstream (Hoagstrom 1997, 1999, 2000). For example, after a long block release in 1995 (32 days greater than 500 cfs, 14.2 m³/s), shiner density at the Brantley Reservoir inflow was very high (73 shiners/ft², 6.8 shiners/m²). These fish were all very small (0.6 in, 15.2 mm). Unfortunately, the high number of shiners is not sustained in the Farmlands reach, and shiner abundance is normally low during winter and spring (less than 1.1 shiners/ft², 0.1 shiners/m²) (Hoagstrom 2000). Inability of the shiner to sustain high densities in the Farmlands is the result of low survival, growth, and recruitment attributed to poor habitat conditions (see Velocity and Depth Preference and Reproduction sections).

D. Status of Species and Distribution

The historic trend in shiner abundance indicates a decline since the 1940s (Hatch et al. 1985, Brooks et al. 1991, Propst 1999). For example, Koster (1957) collected 818 shiners on September 3, 1944, at the U.S. Highway 70 Bridge (University of New Mexico Museum of Southwestern Biology records). In comparison, at the same site between 1992 and 1999, the NMFRO collected a total of 815 shiners in 39 trips (Hoagstrom 2000). In pre-1950 collections shiner represented 37.5 percent of the shiner guild (Platania 1995b) but never reached that level subsequently (Platania 1995b, Hoagstrom 2003). Collections between 1986 and 1990 indicate a further decline in abundance and a reduction in range, although the species still existed within the designated critical habitat reaches (Brooks et al. 1991). Brooks et al. (1991) found that the shiner comprised 3.7 percent of the total number of all shiners collected (5 species) from the Pecos River during 1990, compared to 22.4 percent for all collections prior to 1980 (4 species).

From 1992 to 1999 shiner status improved substantially compared to 1991 (Brooks et al. 1991, 1993, Brooks and Allan 1995, Hoagstrom et al. 1995, Hoagstrom 1997, 1999, 2000, 2001). This was due to the combined effects of increased snowpack and spring runoff, frequent local precipitation, and experimental Sumner Dam operations, all of which contributed to sustaining

perennial flows from Sumner Dam to Brantley Reservoir (Hoagstrom 1999, 2000). These years included base-flow supplementation and a 15-day maximum peak flow restriction on storage transport release duration. However, 2002 was a very dry year with extensive river drying (49 days) and it appears to have impacted the shiner population. In 2003 and 2004, there were 44 and 8 days intermittency, respectively. No intermittency was recorded in 2005. Preliminary data for the last trimester sampling in 2005 indicate a slight increase in either density or relative abundance of shiners over the last trimester of 2004 (S. Davenport, Service, electronic message, 2006b).

From the long-term population surveys that have been conducted in the Rangelands reach, it appears that the prolonged and extensive intermittency that occurred in 2002 and 2003 had a negative impact on the shiner population. Both the relative abundance and shiner density dropped precipitously in the Rangelands reach, where the habitat is the best (Figures 4 and 5). As previously described, shiner density had been showing an overall upward trend until the May-August and September-December 2002 sampling dates (Fagan 2006). Although more limited in scope, work conducted by Valdez et al. (2003) from May to October, 2002, showed the same pattern. Density of shiner at the 3 sites sampled showed marked declines in the October sampling period. Likewise, the relative abundance of shiner at the three sites declined (as calculated from data presented in Valdez et al. 2003). Information from 2004 sampling by the Service indicates that density, relative abundance, and percentage of shiners in the shiner guild were very low at or near the lowest levels since 1992 (Fagan 2006) (Figures 8 and 9).

Although shiner density was greater in 2001 than a decade ago, the extensive intermittency in 2002 through 2003 may have substantially reduced the number of shiners available for breeding in 2004. In the 1990s, shiner numbers increased over a 5-year period (1991 to 1996) largely due to favorable flow conditions and absence of river intermittency. Drought conditions have reduced flows and increased river drying. Because the shiner has a short life span (3 years), extended drought conditions and subsequent river drying has severely reduced the shiner population. Recruitment to the adult population in 2002-2004 may have been low (as reflected in the density figures for 2003-2005), limiting the ability of population to react to the less severe conditions in 2004 and improved conditions in 2005.

E. Analysis of the Species/Critical Habitat Likely to be Affected

The shiner has undergone significant population declines and range contraction in the last 65 years (Service 2003a). It is now restricted to about 186 mi (298 km) from Taiban Creek to Brantley Reservoir. The decline is the result of various alterations to the Pecos River, most notably the diversion of water for irrigation and the storage of water in impoundments. Channel drying was recorded at the Acme gage in 1989 (22 days), 1990 (32 days), 1991 (15 days), 2001 (5 days), 2002 (49 days), 2003 (44 days), 2004 (8 days), and no days in 2005 (USGS stream gage data for Acme gage).

The shiner population is unlikely to expand its distribution because Santa Rosa and Sumner Reservoirs, FSID Diversion Dam, and Brantley Reservoir fragment river habitat and prevent upstream and downstream migration and colonization. Low base flows and river intermittency

also limit movement of the shiner. These conditions persist to the present time. Although the portion of the river in the Tailwaters reach between Taiban Creek upstream to the FSID Diversion Dam (17 mi, 27 km) is almost always wet, shiners do not colonize this area, most likely because the habitat is not suitable (Hoagstrom 2003). The suitability of this area for shiners has not improved since 2003. Brantley Reservoir is a sink for millions of drifting shiner eggs and larvae and prevents downstream colonization (Dudley and Platania 1999); however, some shiners were found below Brantley Reservoir in 2003 (Service 2003b). The survival of these individuals is uncertain, and the habitat between Brantley Reservoir and Avalon Reservoir may not be suitable for persistence of a self-sustaining population. The possibility of naturally increasing the range of the shiner appears remote.

River channel degradation has also impacted the range of the shiner. River channels below dams often become more stable as a consequence of an altered hydrograph (Polzin and Rood 2000, Shields et al. 2000). Exacerbating this effect is the presence of salt cedar. Salt cedar was first observed near Lake McMillan in 1914 and its range expanded quickly thereafter (Thomas 1959). Encroachment of salt cedar has narrowed the river channel, especially in the lower critical habitat, leading to a degradation of shiner habitat. Artificial channel geometry was created between BLNWRMT and McMillan Reservoir through channelization efforts that were exacerbated by salt cedar invasion and reservoir operations (Corps 1999). At the same time, bed sediments were scoured from the Tailwaters reach between Sumner Dam and Taiban Creek confluence, leaving a gravel-armored channel (Tetra Tech Inc. 2000). The only reach that has retained an active river channel is the Rangelands reach between Taiban Creek confluence and BLNWRMT, but channel width and bed mobility progressively decrease downstream into the Farmlands reach (Tashjian 1993, 1994, 1995, 1997; Tetra Tech Inc. 2000). These habitat conditions may have been affected by the low flows in 2002-2003; however, the extent and permanency of such effects is unknown. Higher flows in late 2004-2005 may have eliminated further adverse effects.

Decreased peak flows and extended peak flows for block water releases by Reclamation have altered the natural hydrograph, to which the shiner is best adapted (Cross et al. 1985). There is increasing interest in oil and gas development near the Pecos River and in its flood plain (S. Belinda, BLM, pers. com. 2003). This development could lead to more roads, pipelines, and potential sources of pollution into the Pecos River. Sediment entrapment in upstream and tributary reservoirs limits the amount of sediment available for the development of habitat (Sherrard and Erskine 1991).

Interior Least Tern

Species Description

Least terns are the smallest members of the subfamily Sterninae and family Laridae of the order Charadriiformes, measuring approximately 9 in long with a wing span of 20 in. The least tern is recognized as a distinct species of tern, and the interior least tern as a subspecies, based on studies of vocalizations and behavior (American Ornithologists' Union 1957, 1983; Johnson et al. 1998). Three subspecies of least tern nest in the United States. The California least tern

(*Sterna a. brownii*) nests from Baja California to the San Francisco Bay; the interior least tern (*Sterna a. athalassos*) nests along the major tributaries throughout the interior U.S. from Montana to Texas and New Mexico to Louisiana; and the eastern least tern (*Sterna a. antillarum*) nests along the coast from Texas to Maine. Breeding plumage of terns consists of a black cap, white forehead, throat and underside with a pale gray back and wings, and black-tipped yellow-orange bill. In flight, the tern is distinguished by the long, black outermost wing feathers and the short, deeply forked tail. First-year birds have a dark bill, a dark gray eye stripe, and a dusky brown cap.

Historic and Current Range-wide Distribution

Terns are long-distance migrants that breed in North America and winter in South America. Terns historically bred along the Mississippi, Missouri, Arkansas, Red, Rio Grande, and Ohio River systems (Coues 1874, Youngworth 1930, 1931; American Ornithologists' Union 1957, Hardy 1957, Burroughs 1961, Anderson 1971, Ducey 1981). The range extended from Texas to Montana and from eastern Colorado and New Mexico to southern Indiana. This tern continues to breed in most of its historic breeding range, although its distribution is generally restricted to river segments that have not been heavily altered from historic conditions (U.S. Fish and Wildlife Service 1990). It breeds along the lower Mississippi River from approximately Cairo, Illinois, south to Vicksburg, Mississippi (U.S. Fish and Wildlife Service 1990). In the Great Plains, it breeds along: (1) The Missouri River and many of its major tributaries in Montana, North Dakota, South Dakota, Nebraska, and Kansas; (2) the Arkansas River in Oklahoma and Arkansas; (3) the Cimarron and Canadian Rivers in Oklahoma and Texas; and (4) the Red River and Rio Grande in Texas (U.S. Fish and Wildlife Service 1990). Current wintering areas of the interior least tern remain unknown (U.S. Fish and Wildlife Service 1990). Least terns of unknown subspecies are found during the winter along the Central American coast and the northern coast of South America from Venezuela to northeastern Brazil (U.S. Fish and Wildlife Service 1990).

Life History

Reproductive Biology. Terns are present at breeding sites for 4 to 5 months, arriving from late April to early June (Youngworth 1930, Hardy 1957, Wycoff 1960, Faanes 1983, Wilson 1984, U.S. Fish and Wildlife Service 1987). Predators and other intruders are dive-bombed by adults. Courtship can occur either at the nest site or some distance away (Tomkins 1959). It includes aerial displays involving pursuit and maneuvers, culminating in a fish transfer on the ground between two courting birds. Other courtship behaviors include nest scraping, copulation and a variety of postures and vocalizations (Hardy 1957, Wolk 1974, Ducey 1981). The nest is a shallow, inconspicuous depression in an open sandy area, gravelly patch, or exposed flat. Small stones, twigs, pieces of wood and debris usually lie near the nest. Terns nest in colonies as small as a single pair to over 100 pairs, and nests can be as close as a few feet apart or widely scattered up to hundreds of feet (Ducey 1988, Anderson 1983, Hardy 1957, Kirsch 1990, Smith and Renken 1990, Stiles 1939). Terns usually lay two to three eggs (Anderson 1983; Faanes 1983; Hardy 1957; Kirsch 1987, 1988, 1989; Sweet 1985, Smith 1985) and may renest if their nest is destroyed. Incubation generally lasts 20 to 25 days, but has ranged from 17 to 28 days (Moser

1940, Hardy 1957, Faanes 1983, Schwalbach 1988). Although the female does most of the incubation and brooding, both adults participate. Chick color varies from white to tan with black spots or streaks across back and top of head. Tern chicks hatch within 1 day of each other and stay near the nest bowl for several days. Chicks are fed small minnow-like fish until they fledge at around 20 days. Recently fledged chicks are inefficient predators and continue to receive food from adults for several weeks. Fledglings may disperse from natal colonies within 3 weeks of fledging. Departure from colonies by both adults and fledglings varies, but is usually complete by early September (Bent 1921, Stiles 1939, Hardy 1957).

Growth and Longevity. Young terns are slightly precocial and are brooded for about 6 days after hatching. At that time, they are mature enough to disperse from the nest on the ground. Chicks are able to fly by about 20 days after hatching, but do not become competent at fishing until after migrating from the breeding grounds in fall (Hardy 1957, Tomkins 1959, Massey 1972, 1974). Therefore, they depend on parental care for a short time after they have become strong fliers. Record longevity for a least tern is 24 years (Klimiewicz and Fitcher 1989).

Movements/Dispersal Patterns. Annual and seasonal movements of terns between breeding sites are poorly understood, but are known to occur frequently over significant distances and may occur quickly based on abrupt changes in habitat conditions. Breeding site fidelity is affected by the ephemeral nature of the tern's riverine environment, which prevents some sites from being used in successive years. Localized shifts observed in tern distribution likely result from the interplay of several related ecological factors, including the presence of suitable sandbars, the existence of favorable water conditions during the nesting season, and the availability of food (Hardy 1957). Changes in the microhabitat and social structure within breeding areas often leads to birds changing sites if suitable habitat of higher quality is available elsewhere (Prindiville 1986).

Food and Habitat Requirements. Terns are piscivorous, feeding on small fish in shallow waters of rivers, streams, and lakes (U.S. Fish and Wildlife Service 1990). Moseley (1976) believed terns to be opportunistic feeders, exploiting any fish within a certain size range. Fishing behavior involves hovering and shallow dives over standing or flowing water.

The terns' physical habitat requirements include lack of vegetative cover (Dirks 1990, Ziewitz et al. 1992), open expanses of sand or pebble beach within the river channel or reservoir shoreline, and proximity to stable food sources (Faanes 1983, Dugger 1997, Adolf 1998). The riverine nesting areas of terns are sparsely vegetated sand and gravel bars within a wide unobstructed river channel, or salt flats along lake shorelines. Nesting locations usually are at the higher elevations and away from the water's edge because nesting starts when the river flows are high and small amounts of sand are exposed. The size of nesting areas depends on water levels and the extent of associated sandbars. The Lower Mississippi River is very wide and carries a tremendous volume of water and sand. Sandbars form annually, are washed away, and shift position. Many sandbars are over 3.2 km long and 1.2 km wide. Nest sites are often several hundred meters from the water (Rumancik 1987, 1988). Thus, nesting areas usually are several hundred hectares in size.

Sandbar geophysiography and associated hydrology are integral components of suitable habitat. Bacon (1996) found channel bars chosen for nesting sites by least terns on the Yellowstone River were exposed above river level longer throughout the breeding season than non-nesting habitats. Similarly, Smith and Renken (1991) found that tern colonies along the lower Mississippi River were located on sand islands and sandbars that differed from unused sand islands by the length of time sites were continuously exposed above the river. Most nest colonies on the Yellowstone occurred in a section of the river where channel sinuosity began to increase. Terns prefer sites that are well-drained and well back from the water line. Terns usually nest on sites totally devoid of vegetation, but if present, vegetation is usually located well away from the colony (Hardy 1957, Anderson 1983, Rumancik 1985, Smith and Shepard 1985). Terns also nest in dike fields along the Mississippi River (Smith and Stuckey 1988, Smith and Renken 1990); at sand and gravel pits (Kirsch 1987-89); ash disposal areas of power plants (Wilson 1984, Johnson 1987, Dinsmore and Dinsmore 1988); along the shores of reservoirs (Chase and Loeffler 1978, Neck and Riskind 1981, Boyd 1987, Schwalbach 1988); and at other manmade sites (Shomo 1988). It is unknown to what extent those alternative habitats have replaced productive natural habitat.

Foraging habitat for terns includes side channels, sloughs, tributaries, shallow-water habitats adjacent to sand islands and the main channel (Dugger 1997). To successfully reproduce, productive foraging habitat must be located within a short distance of a colony (Dugger 1997). For example, terns in Nebraska generally were observed foraging within 328 ft (100 m) of the colony (Faanes 1983). Armbruster (1986) recommends that feeding areas for terns be present within 1,312 ft (400 m) of the nesting colony.

Range-wide Population Status and Trends

Over the past century, the number of terns has fluctuated. During the late 1800s, terns declined in numbers due to harvesting for the millinery trade. After the Migratory Bird Treaty Act was passed in 1916 to make commercial harvest illegal, tern numbers increased until the mid-1900s, when alterations of natural hydrologic patterns and urban and industrial development of shorelines led to further population declines. The interior least tern was listed as endangered on June 27, 1985 (50 FR 21784-21792), primarily due to widespread, human-caused stabilization of its normally dynamic riverine habitat. Since the taxonomic status of the interior least tern was not resolved in 1985, the interior population was defined as any least tern nesting more than 50 km from the coast, and this population was listed as endangered independent of taxonomic status (U.S. Fish and Wildlife Service 1985). Barren sandbars, the tern's preferred nesting habitat, were once a common feature of the Mississippi, Missouri, Arkansas, Ohio, Red, Rio Grande, Platte, and other river systems of the central United States. Sandbars are not stable features of the natural river landscape, but are formed, enlarged, eroded, moved, or destroyed, depending on the dynamic forces of the river. Widespread stabilization of major rivers for navigation, hydropower, irrigation, and flood control significantly impaired the dynamic nature of riverine processes (Smith and Stucky 1988). Reduced flooding prevents scouring of sandy islands and shores, allowing vegetation to grow and making the habitat unsuitable for nesting terns. Many of the remaining sandbars became unsuitable for nesting because of vegetation encroachment, or were low and subject to frequent inundation. River channelization, gravel mining and human-

related disturbance (i.e., foot traffic, unleashed pets, swimmers, canoeists and off-road vehicles) also contributed to the decline of this subspecies. Indirect disturbance of tern colonies can result in temporary abandonment of nests (Burger 1981), exposing adults to aerial predation and eggs and chicks to predation and inclement environmental conditions. All of these habitat changes resulted in declines in numbers and distribution of terns that led to its listing as endangered in 1985.

Kirsch and Sidle (1999) compiled tern population data from 1984 to 1995 to assess the range-wide status of the population. Breeding population estimates were compiled for 35 local areas. Large population increases occurred along the middle and lower Mississippi River where approximately 52 to 79 percent of terns nest. The Platte River in Nebraska contained the second largest number of terns (6.2 to 13.6 percent). Two stretches of the Missouri River in North Dakota, South Dakota and Nebraska; Salt Plains National Wildlife Refuge in Oklahoma; Cimarron and Canadian Rivers in Oklahoma; and Falcon Reservoir on the Rio Grande in Texas all typically provided habitat for more than 100 terns annually (Kirsch and Sidle 1999).

The 1995 tern count numbered approximately 8,800 terns in 1995, and exceeded the range-wide delisting numerical recovery objective of 7,000 terns. However, the mean number of terns in 12 of 19 local areas designated in the tern recovery plan (U.S. Fish and Wildlife Service 1990) did not reach corresponding recovery objectives for delisting. These recovery criteria include assuring that essential habitat is protected by removal of current threats and habitat enhancement, establishing agreed-upon management plans, and attaining a population of 7,000 birds at the following levels:

1. Adult birds in the Missouri River system will increase to 2,100 and remain stable for 10 years.
2. Current numbers of adult birds (2,200 to 2,500) on the Lower Mississippi River will remain stable for 10 years.
3. Adult birds in the Arkansas River system will increase to 1,600 and remain stable for 10 years.
4. Adult birds in the Red River system will increase to 300 and remain stable for 10 years.
5. Current number of adult birds in the Rio Grande system (500) will remain stable for 10 years, essential breeding habitat will be protected, enhanced and restored, and terns will be distributed along the Rio Grande and Pecos Rivers.

Overall tern population trends from 1986 to 1995 were positive. However, this positive trend was primarily due to increases in numbers of terns on the lower Mississippi River (Kirsch and Sidle 1999). Annual increase for the entire tern population was approximately 9 percent. When data from the lower Mississippi River was excluded, the annual increase was 2.4 percent (Kirsch and Sidle 1999). Two areas, near the Missouri River in Iowa and Optima National Wildlife Refuge in Oklahoma, had significant negative trends from 1986 to 1995.

During a recent 2005 range-wide tern survey, 4,515 river mi, 12 reservoirs, 61 sand pits, and over 14,000 ac of salt flats were covered (Lott 2006). A total of 17,587 terns were counted in association with 491 different colonies. Terns were detected on 63 out of 74 survey segments.

A majority of adult terns were counted on rivers (89.9 percent), with much smaller numbers at sand pits (3.7 percent), reservoirs (2.7 percent), salt flats (2.1 percent), industrial sites (1.5 percent), and roof-tops (0.3 percent). Similarly, most colony sites were on rivers (82.5 percent) with fewer colonies occurring on reservoirs (6.8 percent), sand pits (6.0 percent), salt flats (2.5 percent), industrial sites (1.8 percent), and roof-tops (0.4 percent). Just over 62 percent of all adult terns were counted on the Lower Mississippi River (10,960 birds on over 770 river mi). Four additional river systems accounted for 33.9 percent of the remaining terns, with 12.1 percent on the Arkansas River system, 10.4 percent on the Red River system, 7.1 percent on the Missouri River system, and 4.3 percent on the Platte River system. Lesser numbers of terns were counted on the Ohio River system at natural, created, and industrial sites along the Ohio and Wabash Rivers (1.5 percent); on urban, industrial, and reservoir sites within the Trinity River system in Texas (1.5 percent); at reservoirs along the Rio Grande/Pecos river system in New Mexico and Texas (0.8 percent), or elsewhere (0.5 percent). Although nearly 63 percent of all individual adult terns were counted on the Mississippi River, the Mississippi River accounted for only 17.9 percent of all colony sites. A higher percentage of all colony sites were reported for the Arkansas (25.9 percent), Red (25.5 percent), and Missouri (19.1 percent) river systems. Less than 7 percent of all colonies were detected on the Platte River and just over 2 percent were on the Ohio and tributaries. Average colony sizes for terns were generally small, between 4 and 29 birds per colony). A strong exception to this rule was the Mississippi River, where average colony size was 119 birds and a single colony had 700 birds. The maximum colony size at any location other than the Mississippi was 130 birds at the mouth of the Canadian River at Eufaula Lake (Lott 2006).

Status and Trends in the Rio Grande/Pecos River System. In 2005, 138 terns were counted at three locations on the Pecos River (nesting on barren alkali “flats” at Bitter Lake National Wildlife Refuge, roosting but not breeding at Brantley Lake State Park in New Mexico, and at Imperial Reservoir in Texas) and at a single reservoir on the Rio Grande (Amistad National Recreation Area) (Lott 2006). Terns are not known to nest on sandbars on either the Rio Grande or the Pecos River. During the 2005 census, water levels at Falcon Reservoir, a historically important nesting area for terns, were high and all tern nesting habitat was presumed to be under water. Therefore, surveys of Falcon Reservoir were not conducted (Lott 2006). Historically, terns have nested at six reservoirs on the Rio Grande/Pecos River system and a single reservoir (O.C. Fischer) on the nearby North Concho River (Kasner et al. 2005). Habitat conditions at Lake Casa Blanca on the Rio Grande and O.C. Fischer Reservoir on the North Concho River may have declined to a point where terns would no longer nest, and no terns were recorded during the census at either of these locations (Lott 2006). The 2005 count of 85 terns at Amistad Reservoir is below average, compared to counts between 1999 and 2004. Large numbers of terns were counted at Falcon Reservoir in the late 1980s and early 1990s. However, habitat conditions have declined since then, and it is unclear how many terns still nest there (Lott 2006). The last time that all major reservoirs were surveyed for this system was in 1989, where 482 birds were present. It is unclear whether numbers have actually declined from this total to the 138 reported during the 2005 census, or if this low number reflects the lack of survey data from Falcon Reservoir (Lott 2006).

Factors Affecting the Species Range-wide

Habitat Loss and Degradation. Remnants of tern habitat remain distributed across much of the species' historic range, although at much reduced levels. Beach habitats are increasingly used for human recreation and residential development; river sandbars have been eliminated by channelization, water diversions, impoundments, and by changes in vegetation resulting from controlled water flow below dams. Alternatively, agricultural fields, parking lots, and flat, graveled roof tops are providing occasional opportunistic nesting sites. In Nebraska, where the central Platte River no longer provides suitable habitat because of upstream diversion, terns are nesting at commercial sand and gravel pits within 0.9 mi (1.5 km) of the Platte (Sidle and Kirsch 1993). In Iowa, terns have nested on fly ash effluent at power plants (Huser 1996).

Channelization, irrigation, construction of reservoirs and pools, and managed river flows have contributed to the elimination of much of the tern's sandbar nesting habitat by engineering wide, braided rivers into a single, narrow channel (Funk and Robinson 1974, Hallberg et al. 1979, Sandheinrich and Atchison 1986). Reservoir storage and irrigation depletions of flows responsible for scouring sandbars has resulted in encroachment of vegetation onto sandbars along many rivers, further reducing tern nesting habitat (Eschner et al. 1981, Currier et al. 1985, O'Brien and Currier 1987, Stinnett et al. 1987, Lyons and Randle 1988, Sidle et al. 1989). In addition, river main stem reservoirs now trap much of the sediment load resulting in less aggradation and more degradation of the river bed, reducing formation of suitable sandbar nesting habitat. With the loss of much tern nesting habitat, predation has become a significant factor affecting tern productivity in many locations (Massey and Atwood 1979, Jenks-Jay 1982).

Human Disturbance. Human disturbance affects tern productivity in many locations (Massey and Atwood 1979, Goodrich 1982, Burger 1984, Dryer and Dryer 1985, Schwalbach et al. 1986, Dirks and Higgins 1988, Schwalbach 1988, Mayer and Dryer 1990). Many rivers have become the focus of recreational activities, and the currently reduced quantity of sandbars has become a recreational counterpart to coastal beaches. Human presence reduces reproductive success (Mayer and Dryer 1988, Smith and Renken 1990). Domestic pet disturbance and trampling by grazing cattle are other factors that have contributed to population decline.

Pollution and Contaminants. Pollutants entering waterways within and upstream of tern breeding areas can negatively impact water quality and fish populations in nearby foraging areas. Strip mining, urban and industrial pollutants, and sediments from non-point sources can all degrade water quality and fish habitat, thereby impacting small fish on which terns depend (Wilbur 1974, Erwin 1983). In addition, because terns are relatively high on the food chain, they can accumulate contaminants that can render eggs infertile or otherwise affect reproduction and chick survival (U.S. Fish and Wildlife Service 1983, Dryer and Dryer 1985). Mercury residues have been found in terns from the Cheyenne River watershed in South Dakota. Organochlorines have been found in terns in South Carolina and California (U.S. Fish and Wildlife Service 1983). Elevated selenium and organochlorine concentrations were found in tern eggs collected on the Missouri River in South Dakota (Ruelle 1991). Allen and Blackford (1997) found 81 percent of 104 least tern eggs collected from the Missouri River exceeded the selenium concentration currently considered safe for avian reproductive success.